DEVELOPMENT OF ANALYSIS TECHNIQUE FOR GAMMA SCANNING AND RADIOTRACER DATA TO IDENTIFY LEAKY HEAT EXCHANGERS AND LIQUID MALDISTRIBUTION IN COLUMNS

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by

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Synopsis

Introduction

Gamma scanning and radiotracer techniques are the two radioisotope applications used to troubleshoot problems in various industrial columns of the chemical and petrochemical industries. These techniques are complementary to each other. Generally, gamma scanning is used for trayed columns, whereas the radiotracer technique is preferred for packed bed columns. Problems like structural damage, weeping, and liquid levels are found in trayed columns. On the other hand, the issues like liquid maldistribution and damaged beds are found in packed bed columns. Most of these problems are detected by the gamma scanning technique. For example, gamma scanning is carried out in a grid along the chords to identify liquid maldistribution in a packed bed column. However, the radiotracer technique is sensitive in detecting liquid maldistribution in the column. In the petrochemical industry, radiotracers are regularly used to identify leakages in pipelines and heat exchangers.

Both these techniques are based on the detection of gamma radiation. Transmitted radiation is measured for a given period using radiation detectors and recorded as data. This data is analyzed by plotting the detector response graphs to identify problems in the columns and to identify leakage in the heat exchangers. The leaky heat exchanger is identified by detecting a peak in the detector response graph. While interpreting the column problems, the information on the internal structure and process parameters of a column are considered appropriately and critically. The success of the techniques depends on the knowledge, experience, and skill of an expert interpreter who predicts the problems.

The motivation of the present work

Gamma scanning and radiotracer techniques have existed for more than 50 years worldwide. In the early years, data was collected manually. Analog strip chart recorders were used to record the data. These charts helped find the cause of troubles in the column. As the technique developed further, these charts became the standard tool for data analysis and identifying various problems in the operational columns. The advancement in science and engineering has improved the method of scanning and the way of data acquisition. However, the data analysis method using the charts remained the same. Various data treatments were implemented to improve these graphs, but column troubles were always interpreted using the graphs only. No other method is reported to investigate the gamma scanning and radiotracer data. The unavailability of any alternate method of data analysis motivated the beginning of this research work. But, creating a new data analysis method for every problem solved using the radiotracer and gamma scanning techniques is out of the scope of this work.

The industry has regularly observed liquid maldistribution in the packed bed columns and leakage in heat exchangers. To interpret these problems, a large amount of data is analyzed by drawing many detector response charts. It may be one of the reasons for the dependence of the success of this technique on an expert interpreter. Therefore, it was decided to work on developing a new alternative method of data analysis for these two case studies.

The objective of this thesis

The main objective of this research is to devise an alternate method to identify liquid maldistribution in the industrial columns using gamma scanning. Also, to determine the leaky heat exchanger using radiotracer techniques. The aim is to provide

quantitative analysis, simplify the data analysis and improve the performance of the investigation.

Description of the research work

Achieving these objectives requires identifying the specific requirements of data interpretation, developing a step-by-step approach to analyze the data, testing the method using simulated data, and validating using the old data of some successful earlier studies. The new process must give better results as an alternative to the existing one. The results of the test and validation are discussed.

In the newly developed segmented FFT data analysis method, the data is first divided into small segments using column details to identify liquid maldistribution. While the radiotracer data is divided using equal data length to identify a peak. Then, the FFT algorithm transforms each segmented data into the frequency domain. The magnitude of the first and/or second coefficient of the Fourier series is used for quantitative analysis. Direct and ratio-based comparison methods are applied to know the segment-wise status. The method is first tested using simulated data. After successful testing, it is validated by using actual data of previous studies by verifying its results with the earlier results. It is observed that the results of the new method of data analysis match the old results.

The actual data of studies were selected to validate the method to detect a leakage peak and identify liquid maldistribution. These studies were carried out earlier, and their results were derived using the traditional method of data analysis. The results of these studies were already published. The analysis of the actual data from gamma scanning and radiotracer studies using the proposed segmented FFT method shows the same results as that of the traditional method. Therefore, this new method is a complementary alternative

to the traditional data analysis method to identify leaky heat exchangers. And to identify liquid maldistribution in the columns, too.

The thesis provides an alternate way of data analysis for the two case studies. The work reported in the thesis has been carried out under the supervision of Prof V. N. Yelgaonkar and supported by Chief Executive, BRIT.

Conclusions

It is observed that the newly developed segmented FFT data analysis method supports graph-less analysis of the radiotracer data. Also, it can quickly analyze the data to identify a leaky heat exchanger and calculate its leak rate. Further, it reduces the probability of human errors, which may happen while analyzing the data using graphs. Data analysis using the new segmented FFT method has reduced the complexity and simplified data analysis. It shows advantages like easy analysis, faster results, support for correct decision-making, and reliable outcomes. The new method shows superiority over the traditional graph-based analysis method by being simple, fast, and quantitative. However, its success largely depends on proper segmentation of the data and the correct reference value of comparison.

List of Publications based on the research work

- Walinjkar P. B., Yelgaonkar V. N., *Radiation Based Advanced Leak Detection Technique for Indian Refinery*, International Journal of Research in Engineering and Science (IJRES), Volume 8 Issue 11, 33-37, (2020).

- Parag Walinjkar, and V N Yelgaonkar, *Gamma Scan Data Analysis using Segmented FFT Method to Verify Liquid Maldistribution in Distillation Column of VDU*, Indian Journal of Pure & Applied Physics Vol. 60, February 2022, pp. 101-104. (2022). http://nopr.niscair.res.in/handle/123456789/59304

Invited Talks

1) “Gamma Scanning of Columns”, Distillation Experts Conclave 2018, September 24-25, 2018.

2) “Gamma scans - A tool for insights into the problems in distillations columns”, Distillation Experts Conclave Virtual 2021, August 3-6, 2021.

Proposed contents of the thesis

The thesis presents a newly developed segmented FFT method to analyze the data of gamma scan and radiotracer studies. It describes the newly developed method's theory, technique, and testing. Chapter 1 of the thesis describes the applications of gamma scanning and radiotracer techniques. It also includes the motivation and objective of the research work. Chapter 2 gives the background of Gamma scanning and radiotracer techniques. It illustrates various common problems observed in distillation columns, followed by a brief mention of the principle of the gamma scanning and radiotracer technique and its basics. The chapter also covers the conventional leaky heat exchanger identification method and its limitations. It also covers the traditional way of data analysis to identify leaky heat exchangers and liquid maldistribution, its problems, and limitations Chapter 3 describes the theory of segmented FFT, the development of the segmented FFT method, and its feasibility study for its application to the gamma scan and radiotracer data. Chapter 4 describes some vital information on gamma scanning and radiotracer studies. It also describes data acquisition systems, radiation detectors, and the characteristics of gamma sources. The chapter also emphasizes measurement errors and how to minimize them. Chapter 5 describes the validation of the newly developed segmented FFT method to identify leaky heat exchangers, using the actual data from radiotracer studies carried out earlier. These studies successfully identified the leaky heat exchangers by analyzing the data using the conventional graph-based method. The chapter also compares the new approach with the traditional way. Chapter 6 describes

the validation of the newly developed segmented FFT method to identify the liquid maldistribution in the column and its cause, using the actual data of the earlier studies. These studies had identified the region of maldistribution and successfully identified its cause by analyzing the data using the conventional graph-based method. The chapter also describes the outcome of comparing the new approach with the traditional. Finally, chapter 7 describes the conclusions drawn based on the results obtained during the testing and validation of the new segmented FFT method.